

The University of Chicago

THE AFFECTIVE VALUES OF COLOR COMBINATIONS

A PART OF A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE
BIOLOGICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

1935

By
CH'UAN-FANG LO

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THE AFFECTIVE VALUES OF COLOR COMBINATIONS

By CH'UAN-FANG LO, University of Chicago

The purpose of this experiment is fourfold: (1) to study whether the affective values of binary color-combinations are a function of the spectral positions (or approximate wave-lengths) of the components; (2) to test whether the pleasantness of a color-combination is determined by the pleasantness of the individual constituents; (3) to compare the affective reactions of several groups of people with varied amounts of art-training or art experience; and (4) to examine sex and racial differences in color-combination preferences.

METHOD

Materials. In this experiment, 18 Milton-Bradley colors were chosen as approximates to spectral colors. It is acknowledged that actually the pigmentary colors are less pure than the spectral colors. The colors of the Milton-Bradley Pure Spectrum Scale are: violet-red, red, orange-red, red-orange, orange, yellow-orange, orange-yellow, yellow, green-yellow, yellow-green, green, blue-green, green-blue, blue, violet-blue, blue-violet, violet, and red-violet. Of these 18 colors, violet-red and red-violet are non-spectral, but are included to complete the Milton-Bradley color circle. The given approximate wave-lengths for the Milton-Bradley Standards are: red 6571m μ , orange 6085m μ , yellow 5793m μ , green 5164m μ , blue 4695m μ , and violet 4210m μ .

The colored papers were first cut into strips $\frac{1}{2}$ in. wide and 3 in. long. Two strips of each color were used for every combination, and the strips were arranged alternately to form a simple rectangle, mounted on a card 2 in. x 3 in. with no margin. Since each of the colors was combined with every other color, there were altogether 153 combinations. All the cards were enveloped in cellophane to keep the colored papers clean.

Procedure. The whole set of 153 cards was presented to every *S* under ordinary daylight. The table on which the cards were placed was covered with a piece of black velvet to provide a uniform background. On the table were laid 10 white cards in one horizontal row, numbered from 1 to 10, to represent a scale of 10 steps. *S*'s task was simply to sort and distribute all the color-cards into ten piles. The written directions were as follows:

Here are 153 color-cards. Each card is a combination of two colors. All you have to do is to sort these cards into 10 piles, which form a scale of values from the most unpleasant to the most pleasant color-combinations. In pile 1, for example, put those combinations you dislike most, and in pile 10 those you like best. Think of each color-combination as a playing-card back design, and let your first impression guide you. Only one card should be exposed at a time. When you have sorted all

* Accepted for publication July 24, 1935. This study was directed by Professor L. L. Thurstone.

the cards, you may turn over the cards in each pile to see whether they seem equally pleasant or unpleasant to you. You may then shift any card to any other pile.

The Ss were allowed all the time they wished.

Subjects. Altogether, 250 adults served as Ss in this experiment. The author acted as *E* throughout the study. The Ss were divided into four groups: non-artists, art students, artists, and Chinese non-art students. The Ss of the first three groups were American; and there was an equal number of men and women in each group. In the Chinese group there was a predominant number of men. Most of the non-artists were undergraduates and graduate students in the University of Chicago. The art students were from the Art Department of the University of Chicago, the School of the Art Institute of Chicago, the Chicago Academy of Fine Arts, and the American Academy of Art. The artists were from 11 different art studios in downtown Chicago.

RESULTS

For each group, the number of times each color-combination appeared in each of the 10 piles was first registered. The median was then calculated. It was the point at which 50% of the group placed the card. This was taken as the scale value of the color-combination. The scale values of 153 color-combinations as determined from the reactions of four different groups of Ss are presented in Tables I and II. More than 65% of the color-cards were placed in the lower five piles by the non-artists (American). Art students placed 60% of the cards in the lower five piles; and artists about 57%. The scale values determined by non-artists range from 0.90 to 6.9. The range for art students is from 1.0 to 7.4, and for artists, from 1.3 to 8.0. These results show that more color-combinations were judged unpleasant than pleasant.

We have plotted 18 curves showing the affective values of color-combinations in relation to the spectral positions of the components. They are not here reproduced, but can be reconstructed from the data given in Tables I and II. When we compare the shapes of all the curves for non-artists, we notice that some have similar shapes, and others are similar in part. The curves which are most similar in shape are those for similar colors. We cannot say that the spectral position of any one color absolutely determines the affective value of a combination of which it is a component, since in a binary combination we have to do with two colors. But the relative affective values of the colors for binary combinations may be estimated by calculating for each color the average scale value of all its combinations. In Table III are listed in order the average scale values of 16 spectral colors when used in binary combinations. The highest affective value belongs to blue combinations, while red combinations have the lowest affective value.

TABLE I
SCALE VALUES OF 153 COLOR COMBINATIONS AS DETERMINED BY AMERICAN AND CHINESE NON-ARTISTS
American non-artists

	VR	R	OR	RO	O	YO	OY	Y	GY	YG	G	BG	GB	B	VB	BV	V	RV
VR	1.2	0.9	2.1	2.6	2.7	2.7	3.0	3.2	2.5	3.5	3.2	2.9	2.7	2.5	2.3	2.9	1.8	2.3
R			3.4	3.1	3.2	3.2	3.9	3.6	2.6	3.3	3.3	3.4	3.2	3.4	2.4	2.3	1.6	2.2
OR				2.2	3.8	3.9	3.9	4.3	3.5	3.7	4.2	4.3	4.8	5.1	4.8	3.3	3.1	2.7
RO			1.9		4.2	4.1	4.1	4.1	3.3	3.7	4.2	4.0	4.5	4.6	4.6	3.7	3.1	2.8
O					4.0	4.0	4.6	4.9	3.1	3.3	4.0	3.5	4.3	5.2	4.0	4.0	3.5	2.9
YO			2.6	0.9			3.2	2.8	1.9	3.3	4.5	4.1	5.3	5.7	4.7	4.1	3.7	3.9
OY			5.1	3.5	4.1	2.1		2.1	2.4	3.9	5.3	4.4	5.8	6.4	5.3	4.8	3.9	3.8
Y			4.4	4.6	5.1	2.5	0.9		1.9	3.7	5.5	5.1	5.8	5.7	5.5	4.9	4.1	4.6
GY			4.0	4.8	4.3	2.3	2.4	1.8		3.7	4.3	3.5	3.7	4.6	4.0	3.7	3.4	3.6
YG			5.1	4.0	4.1	4.1	3.8	3.8	1.6	4.7	5.5	4.0	4.3	4.4	5.1	4.0	3.9	4.0
G			4.7	4.4	4.0	4.2	5.8	5.8	4.8	4.8	4.8	3.6	4.4	4.9	4.8	4.4	4.2	4.5
BG			3.5	3.0	3.0	4.3	4.3	4.6	4.0	4.1	2.4	3.6	5.5	6.2	5.8	4.7	4.3	4.3
GB			4.6	3.9	4.1	5.3	5.0	5.2	5.2	5.0	4.6	3.6	4.6	6.9	5.8	4.7	4.3	4.3
B			5.4	4.8	5.3	5.6	5.2	6.2	5.1	6.1	5.6	5.7	4.6	2.5	3.6	4.2	3.2	2.9
VB			4.0	4.6	4.9	4.7	5.7	6.1	5.3	6.0	5.6	5.2	4.2	3.3	3.6	4.2	3.2	2.9
BV			4.0	3.8	4.6	4.5	4.8	5.2	4.6	5.0	4.8	4.6	2.9	3.2	1.8	3.3	3.1	3.8
V			1.8	3.6	3.7	4.0	4.6	3.9	4.8	5.1	4.6	4.4	3.6	2.6	2.6	1.8	3.0	2.8
RV			2.5	3.4	3.0	4.1	4.2	4.4	4.4	4.0	5.0	3.7	3.1	2.7	3.2	2.1	1.6	2.8

Chinese non-artists

TABLE III

RELATIVE AFFECTIVE VALUES OF SPECTRAL COLORS IN BINARY COMBINATIONS

Color-combination	Av. scale value	Color-combination	Av. scale value
Blue	4.69	Yellow-green	3.86
Green-blue	4.67	Blue-violet	3.79
Green	4.41	Orange	3.66
Blue-green	4.35	Red-orange	3.57
Violet-blue	4.32	Orange-red	3.54
Yellow	4.25	Violet	3.34
Orange-yellow	4.18	Green-yellow	3.18
Yellow-orange	3.90	Red	2.90

Geissler's law of color-combination. In his study of the affective tone of color-combinations, Geissler formulated the following law: "The greater the pleasantness of the individual constituents, the greater will be the pleasantness of the combination."¹ This law has been tested by various investigators,² and quite recently Thurstone developed a new mathematical method of testing it which was used in Ofner's study.³

Starting upon the assumption that the scale value of a color-combination is due principally to a mere sum of the scale values of the separate components, equations for the derivation of the theoretical scale values of single colors were worked out. These equations are:

$$X_{2,1} = X_1 + X_2 \dots\dots\dots [1]$$

in which $X_{1,2}$ represents the scale-value of the combination of colors 1 and 2, and X_1 and X_2 represent the scale-values of the separate components;

$$\Sigma X_{1,k} = (n-1) X_1 + \Sigma X_k - X_1 \dots\dots\dots [2]$$

in which $\Sigma X_{1,k}$ is the sum of the combination scale-values of color number 1, and ΣX_k is the sum of the separate scale-values;

$$\Sigma X_{k,k} = 2(n-1) \Sigma X_k \dots\dots\dots [3]$$

in which $\Sigma X_{k,k}$ is the sum of all the combination scale-values, and ΣX_k is the sum of all the separate scale-values. ΣX is obtained by dividing $\Sigma X_{k,k}$ by $2(n-1)$. When this is known, the scale-values for the separate colors can be derived from Equation [2]:

¹ L. R. Geissler, The affective tone of color combinations, *Titchener Commemorative Volume*, 1917, 162.

² M. F. Washburn, D. Haight, and J. Regensburg, The relation of pleasantness of color combinations to that of colors seen singly, this JOURNAL, 32, 1921, 145-146; M. Yokoyama, Affective tendency as conditioned by color and form, *idem*, 81-107; W. E. Walton and B. M. Morrison, A preliminary study of the affective values of colored lights, *J. Appl. Psychol.*, 15, 1931, 294-303.

³ Marion Ofner, *The Affective Values of Color Combinations*, M.A. thesis, University of Chicago, 1934.

$$\Sigma X_{1,k} = (n-1) X_1 + \Sigma X_k - X_1 \dots\dots\dots [2]$$

$$X_1 = (\Sigma_{1,k} - \Sigma X_k) / (n - 2).$$

Similarly,

$$X_2 = (\Sigma X_{2,k} - \Sigma X_k) / (n - 2),$$

and so on for all the single colors. The theoretical scale-value for the combination of colors 1 and 2 is merely the sum of X_1 and X_2 .

The test of Geissler's law is to be found in the degree of agreement between the theoretical scale-values of the color-combinations thus derived, and the experimental scale-values. We have calculated by the same technique the theoretical scale-values of all of the 153 color-combinations. It was found that the discrepancies between the calculated scale-values and the experimental scale-values as determined by non-artists vary a great deal. The mean discrepancy is 0.53. The correlation between experimental scale-values and calculated scale-values is $0.67 \pm .03$. Geissler's law does not apply to all cases of color-combinations; and it seems dangerous to predict the pleasantness of a color-combination on the basis of the pleasantness of its constituents.

Effect of training. In Table IV are shown the correlations between different groups of Ss. The correlations are not of the same order, but are all positive, which indicate the presence of some common factor in the

TABLE IV
CORRELATIONS BETWEEN DIFFERENT GROUPS OF SUBJECTS

	Non-artists	Art students	Artists
Non-artists	(.78)	.64 ± .03	.41 ± .04
Art students	.64 ± .03	—	.79 ± .02
Artists	.41 ± .04	.79 ± .02	—

affective reactions of all groups, with or without art training. We may generalize that the amount of agreement in color-combination preferences decreases with increase in the amount of art training in one of the two groups. That people with some art training agree more among themselves than with non-artists is indicated by the relatively high correlation between art students and artists.

Sex and racial differences. In order to compare sex differences in color-combination preferences, the 200 American subjects were re-classified into four groups: men and women without any art training, and men and women with art training. Scale-values for all 153 color-combinations were calculated for each group. Their correlations are presented in Table V. It appears that when both men and women receive art training, differences in color-combination preferences due to sex are much reduced. Two groups which differ in sex and in art training agree less than two groups which differ only in sex. On the whole, the sex differences are not so great as differences due to art training.

Racial differences in color-combination preferences between Chinese and American non-artists are negligibly small. The correlation in scale-values is $0.73 \pm .025$, which is almost as high as the self-correlation for the

TABLE V
CORRELATIONS BETWEEN MEN AND WOMEN

	Men without art training	Women without art training	Men with training	Women with training
Men without art training	—			
Women without art training		$.59 \pm .035$	$.48 \pm .042$	$.41 \pm .045$
Men with training	$.59 \pm .035$	—	$.48 \pm .042$	$.62 \pm .033$
Women with training	$.48 \pm .042$	$.48 \pm .042$	—	$.78 \pm .021$
	$.41 \pm .045$	$.62 \pm .033$	$.78 \pm .021$	—

American non-artists. But the correlation between Chinese non-artists and American art students is only $0.43 \pm .044$; and the correlation with American artists is as low as $0.19 \pm .052$. Art training, or art experience, apparently has greater influence in such matters as color preference than race or culture.

SUMMARY AND CONCLUSIONS

An experiment on the affective values of 153 binary combinations of 16 spectral and 2 non-spectral colors was performed on 100 American non-artists, 50 art students, 50 artists, and 50 Chinese students without art training. The combinations were presented in the form of color-cards, and the subjects were asked to sort the cards into ten gradations of pleasantness-unpleasantness. The results of the experiment lead to the following conclusions.

(1) All groups of Ss found more unpleasant than pleasant color-combinations, but art students and artists reacted more favorably than non-artists.

(2) Colors at the two ends of the spectrum were found to make the most unpleasant combinations. For that portion of the spectrum from red to blue, it may be said with one or two exceptions, that the affective values of the spectral colors in binary combinations increase with decrease in wave-lengths, but beyond the most saturated blue, affectivity decreases. The most favored spectral positions for binary combinations are represented by blue, green, and yellow. That combinations of the longest and shortest wave-lengths should be judged most unpleasant might be due to the fact that colors at the ends of the spectrum are darker than the other colors. Colors whose spectral positions are close together may produce either pleasant or unpleasant combinations.

(3) The pleasantness of a color-combination is not always a mere sum of the pleasantness of its constituents.

(4) Color-combination preferences between any two groups of people vary according to the amount of art training.

(5) Sex and racial differences in color-combination preferences are not as great as differences due to art training.

(6) A number of factors other than the spectral order of the colors may have been of influence in the determination of the affective values of the combinations. Such factors are color-pattern, purity of colors, proportion, and background. Variations in any of these may be expected to give different results.

